Framework for Assessing Cost-Effectiveness of Mercury Control Policies

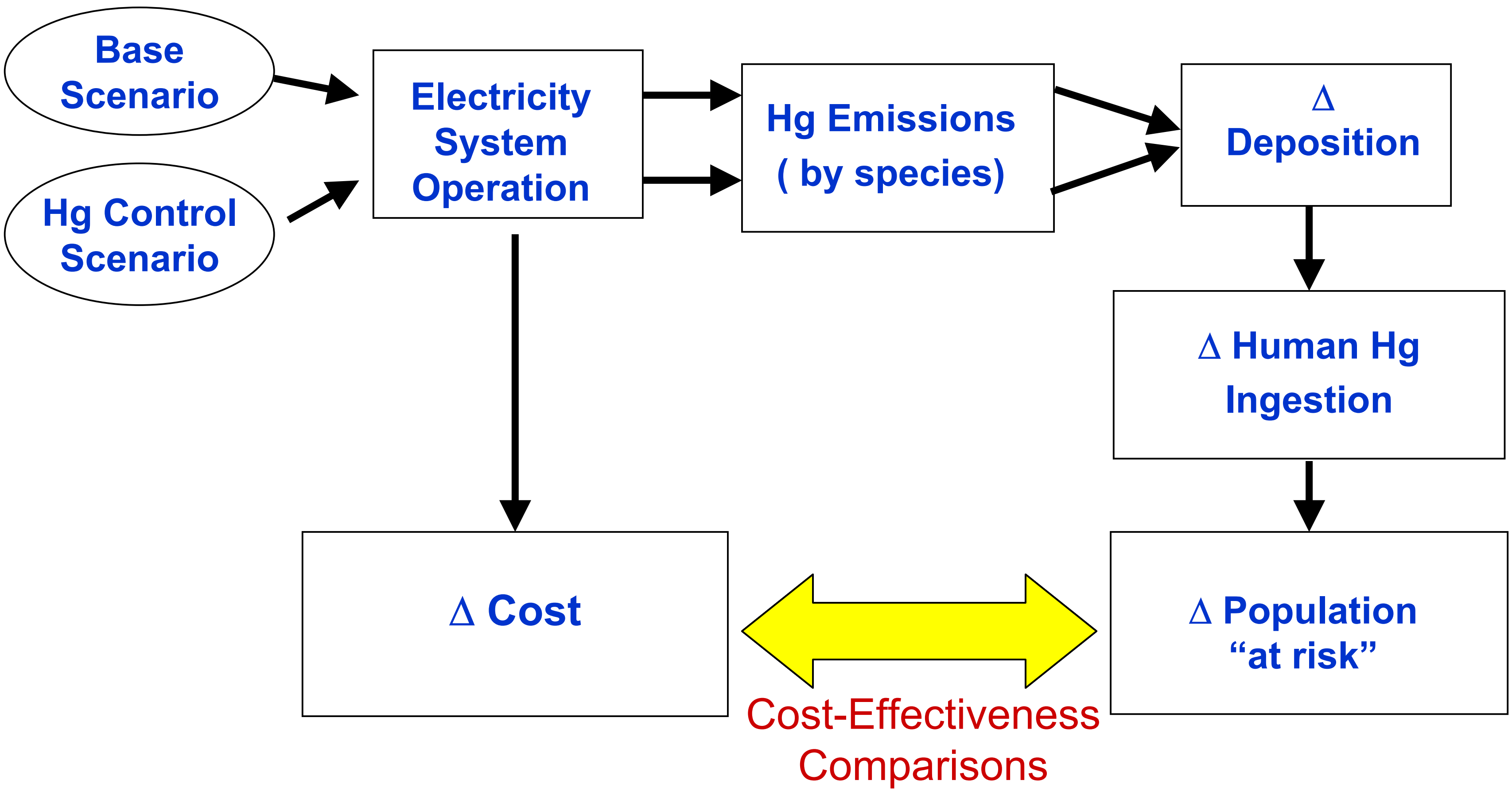
Anne Smith
Brian Lonergan
John Rego
Charles River Associates
with
Chris Whipple
Environ International

NETL Valuing Externalities Workshop
McLean, VA
February 20-21, 2003

Introduction

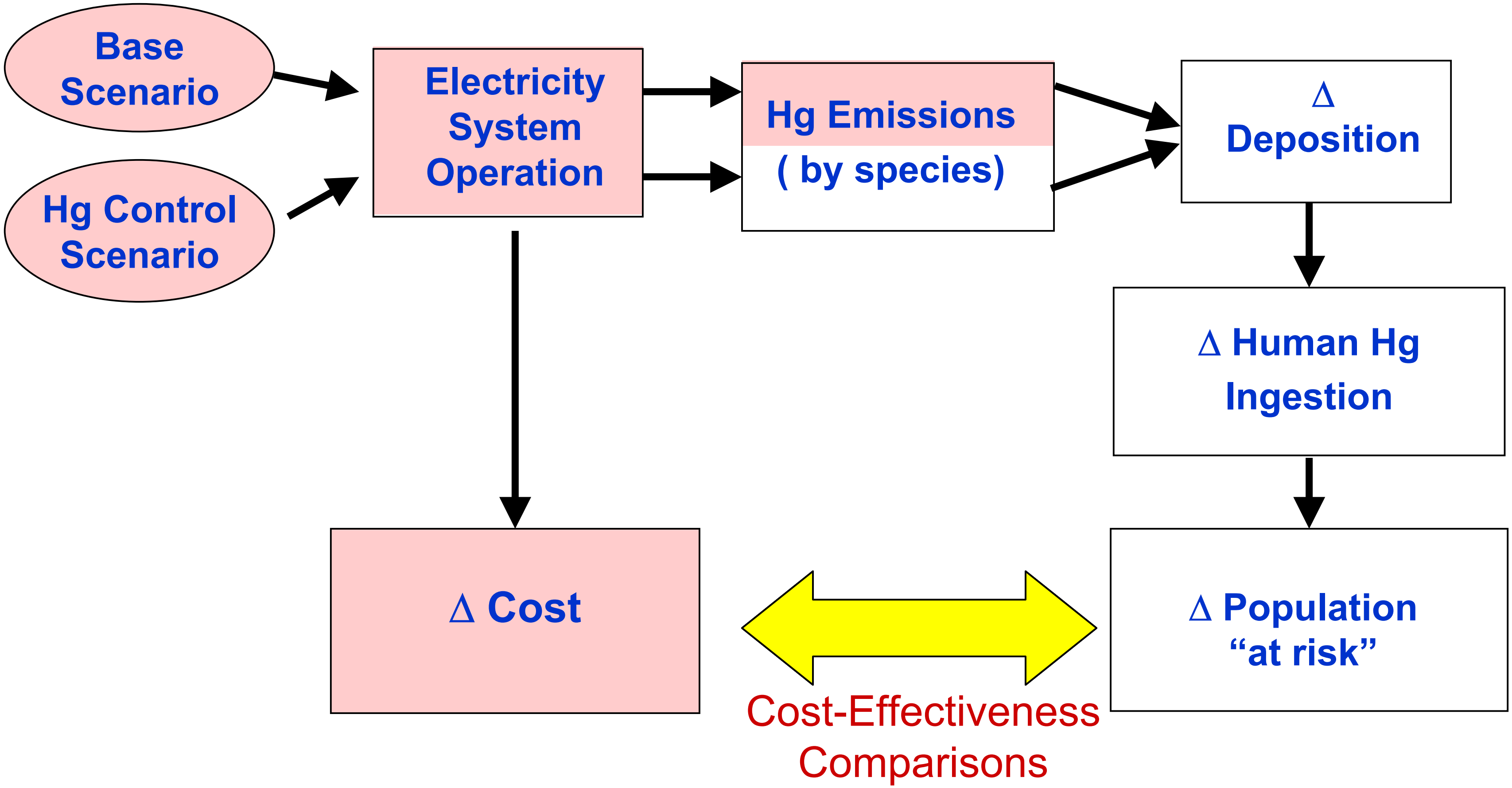
- EPRI-funded project.
- Develop a "cost-effectiveness framework" for exploring utility sector Hg emissions controls.
  - Integrate information on the economic and environmental impacts of controlling Hg emissions.
  - Allow exploration of alternative Hg control options.
  - Work still in initial stages.
- In this presentation:
  - Synopsis of initial framework and its elements.
  - Preliminary application (Clear Skies Act).

Current Elements of Integrated Framework



Note: The **Delta (Δ)** symbolizes a change between the Base and the Hg control policy scenario

Estimating the Electric System Responses to a Hg Control Scenario



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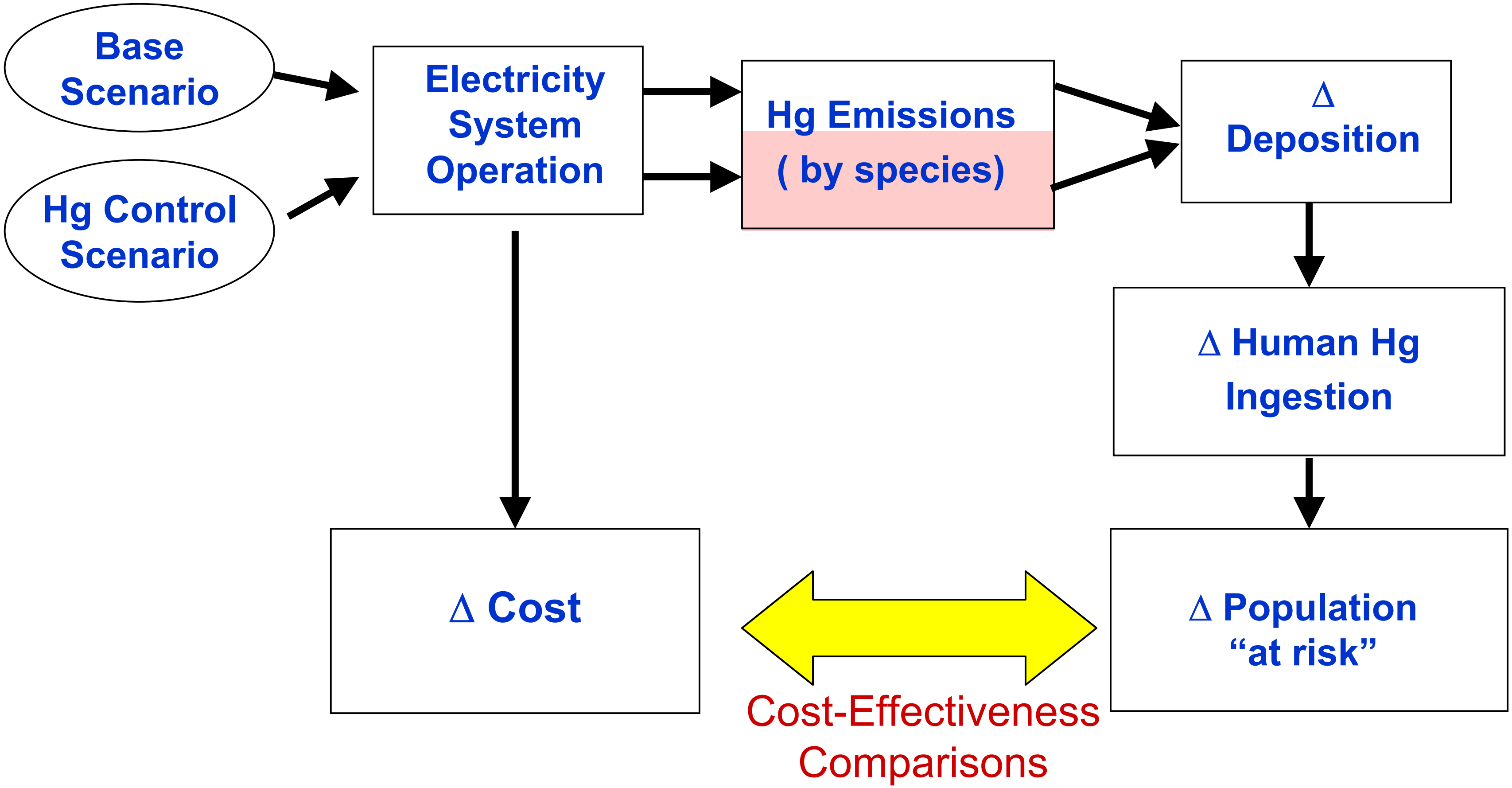
EPMM Model for Multi-Pollutant Policy Simulation

- **EPMM-- linear-program simulation of US electricity system**
  - 32 regional electricity markets
  - Interconnected by limited transmission capacity
- **Finds least-cost way to serve electricity demand & meet:**
  - Emissions caps.
  - Transmission limits.
  - Reserve requirements.
  - Various other system and unit constraints.

Key Outputs of EPMM

- Numbers and combinations of control retrofits
- Capacity & its utilization
- Fuel consumption
  - Including coal choices by rank, sulfur, and Hg contents
- Wholesale electricity prices
- Emissions allowance prices
- Emissions of SO_2, NO_x, carbon, and total Hg
- Total System Generation Costs
  - Present value
  - Annual costs (including annual capital charges)

Estimating the Species of Hg Emitted



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EPMM Outputs Are Combined with ICR-Based Relationships To Speciate Hg Emissions

- Numbers and combinations of control retrofits
- Capacity & its utilization
- Fuel consumption
  - Including coal choices by rank, sulfur, and Hg contents
- Wholesale electricity prices
- Emissions allowance prices
- Emissions of SO_2, NO_x, carbon, and total Hg
- Total System Generation Costs
  - Present value
  - Annual costs (including annual capital charges)

Subsidiary Calculations for Speciating Emissions

EPMM:
Coal type
(rank, Hg content)

EPMM:
Capacity
(PM control, FGD, SCR, ACI)

Total tons inlet Hg for each coal rank & unit configuration

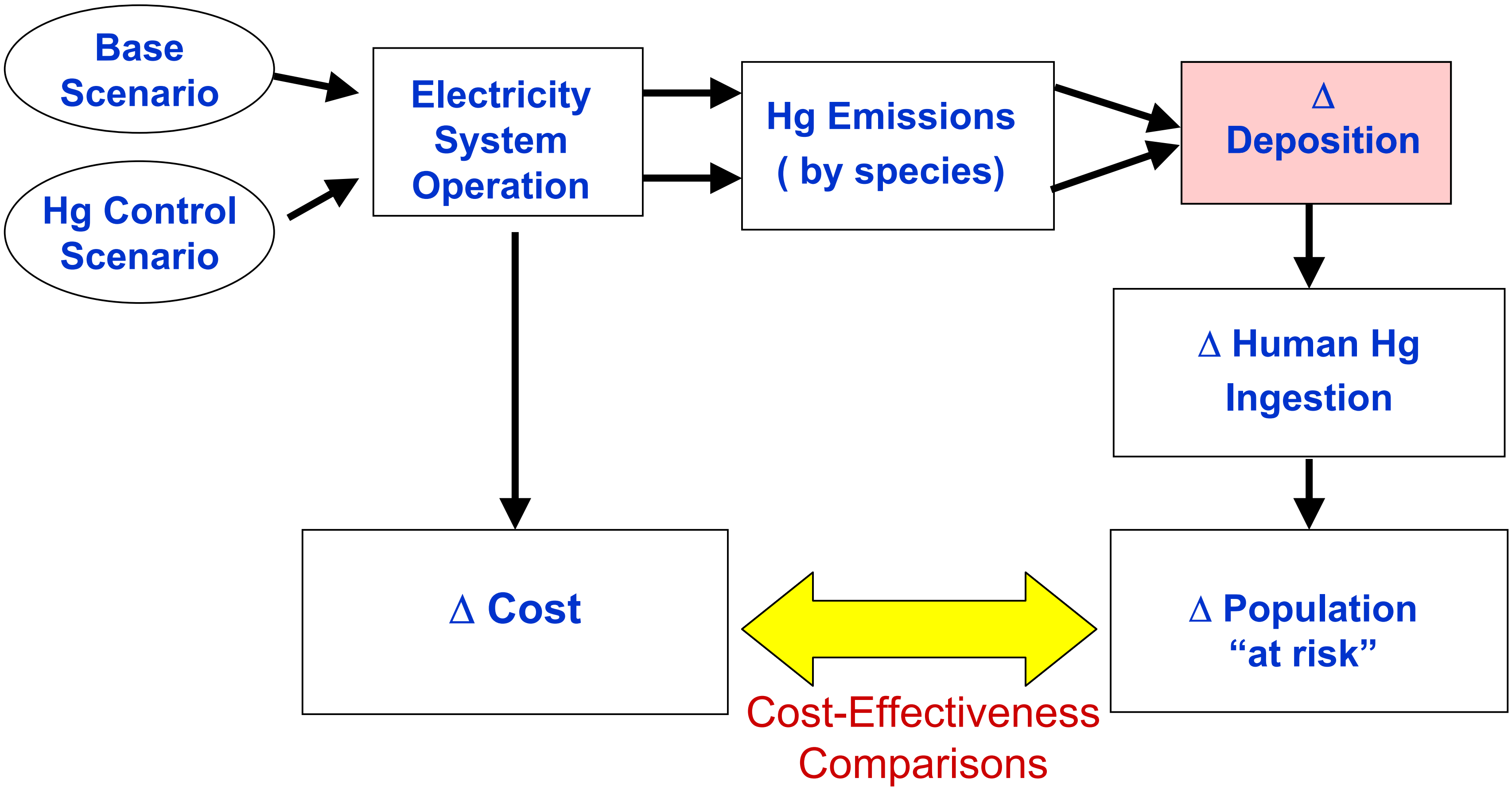
Apply equations for % removed & % Hg^0
(from EPRI Report, based on ICR data analysis)

Framework data
(consistent with EPMM total Hg emissions results)

Tons emitted Hg^0

Tons emitted Hg^{2+}

Estimating Deposition Changes



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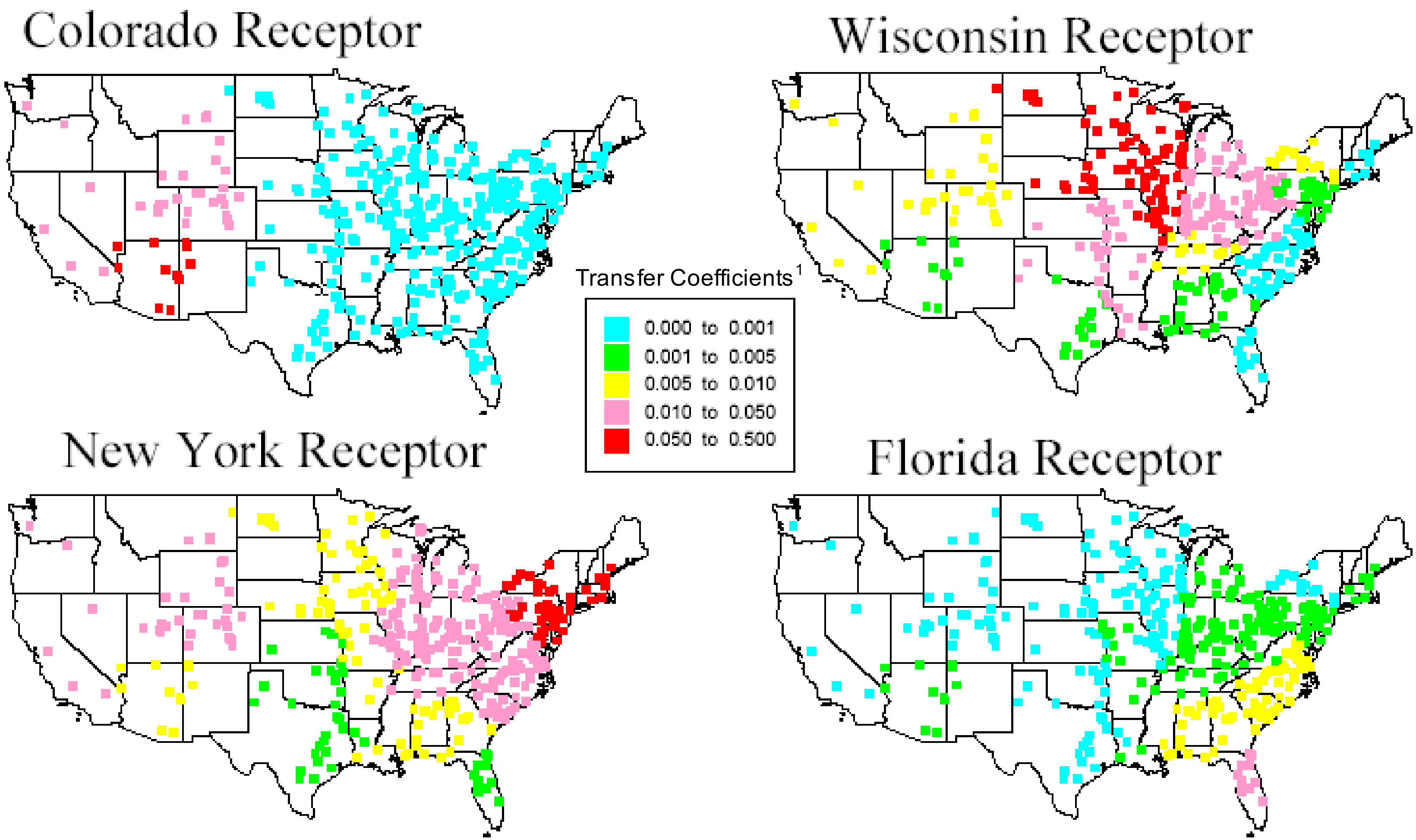
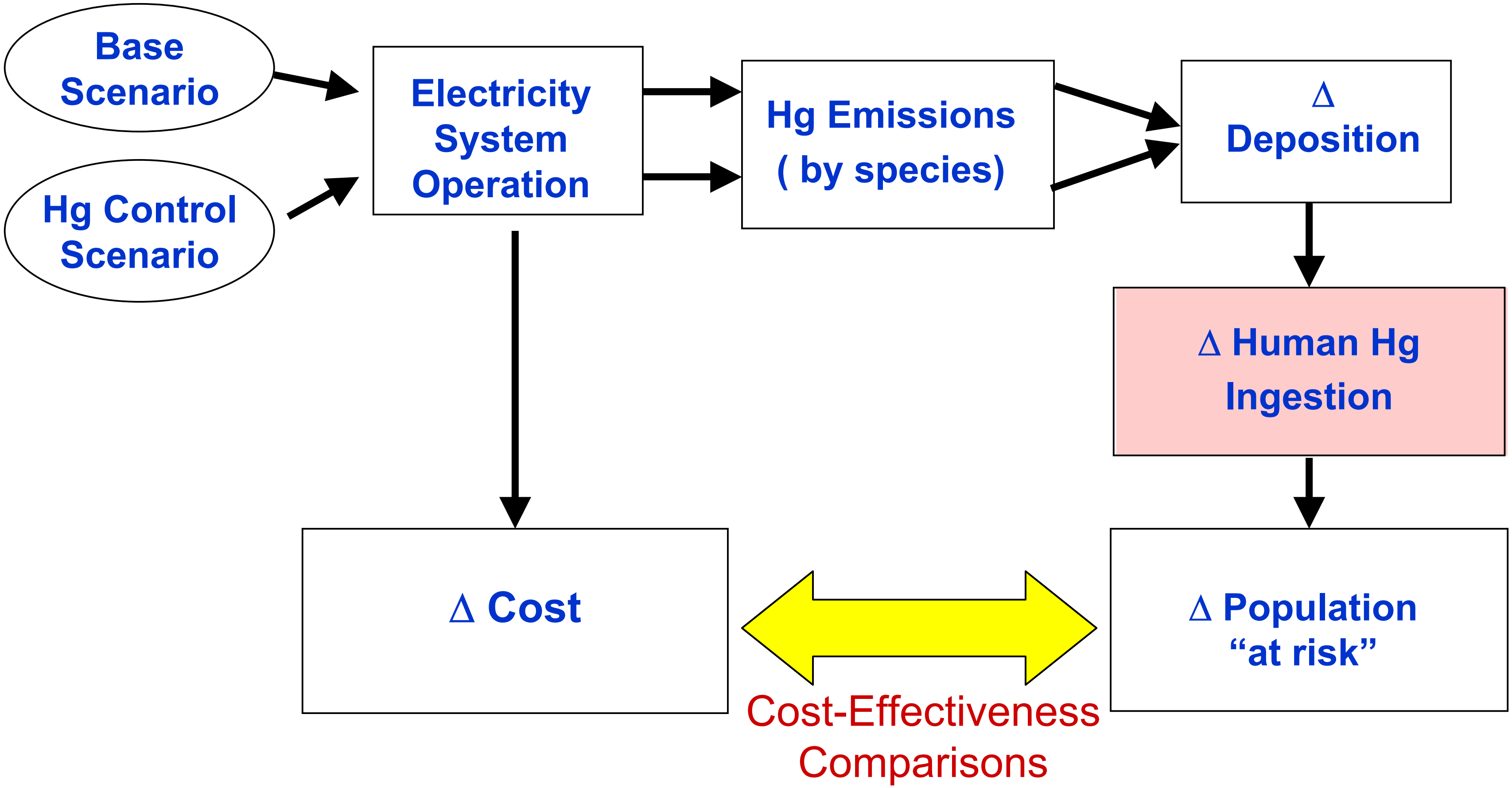
“Transfer Coefficients” for Hg^0 and Hg^{2+} by AER from Global Atmospheric Chemistry Model



[1]Total Deposition / Total Hg Emissions

Estimating Changes in Human Doses



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What Does a Deposition Change Imply for Change in Hg Consumed?

- Currently unknown.
- Possibilities of concern:
  - That concentrations of MeHg in fish flesh come from non-atmospheric sources.
  - That concentrations of MeHg in fish flesh will take some period of time before they fully reflect impact of changes in Hg deposition.
- "Core" assumptions used in framework:
  - An x% change in regional deposition of Hg implies an x% change in concentrations in all wild freshwater fish flesh.
  - The full x% change appears instantly in fish being consumed.
  - This approach minimizes chances of understating the benefits for a given investment in utility Hg emissions reductions.

Human Hg Exposure: Estimating Relevant Portion of Fish Consumption

- Entire human MeHg concentration is attributable to fish meals.

- Change in human MeHg concentration due to policy scenario will be based on fraction of all fish meals that come from "relevant" fish.
  - U.S. Hg deposition changes do not measurably affect the MeHg content of saltwater or farmed fish.
  - Change in MeHg content in wild, freshwater fish is proportional to change in Hg deposition in that year.
  - 20% of catfish, trout, "other", and "unknown" freshwater fish meals are classified as wild freshwater fish.

Human Hg Exposure: Fish Consumption from NHANES data

Fish Type	Weighted Ave Number of fish meals in the past 30 days	Percent of Fish meals
All Fish	8.22	100.00%
Freshwater, excluding other and unknown	0.997	12.13%
Freshwater, including other and Unknown	2.6	31.63%
Freshwater, excluding catfish, trout, other and unknown	0.129	1.57%
Assumed 20% of Catfish, trout, other and unknown are WILD FRESHWATER FISH	0.6232	7.58%

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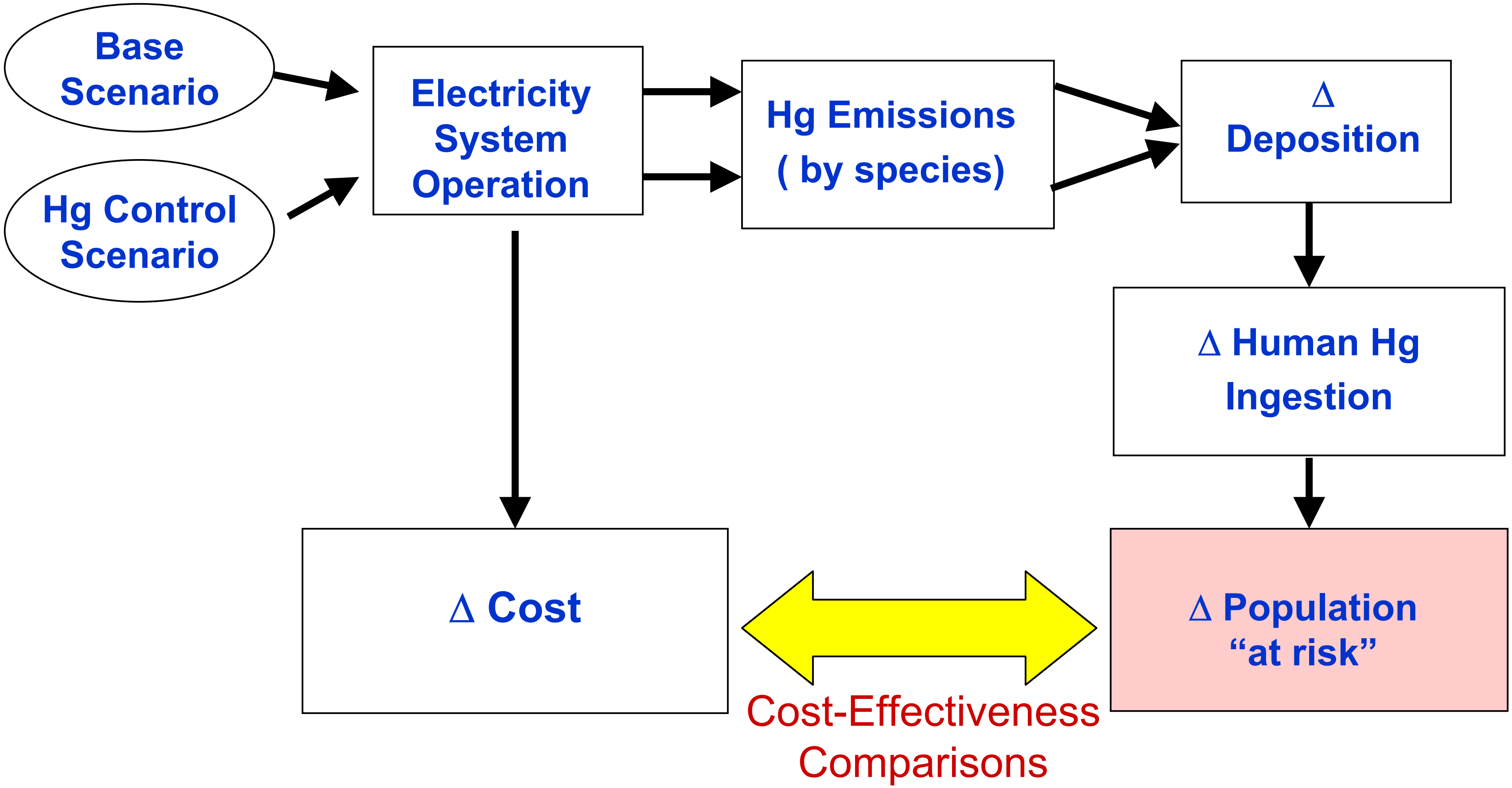
Estimating Changes in Risk



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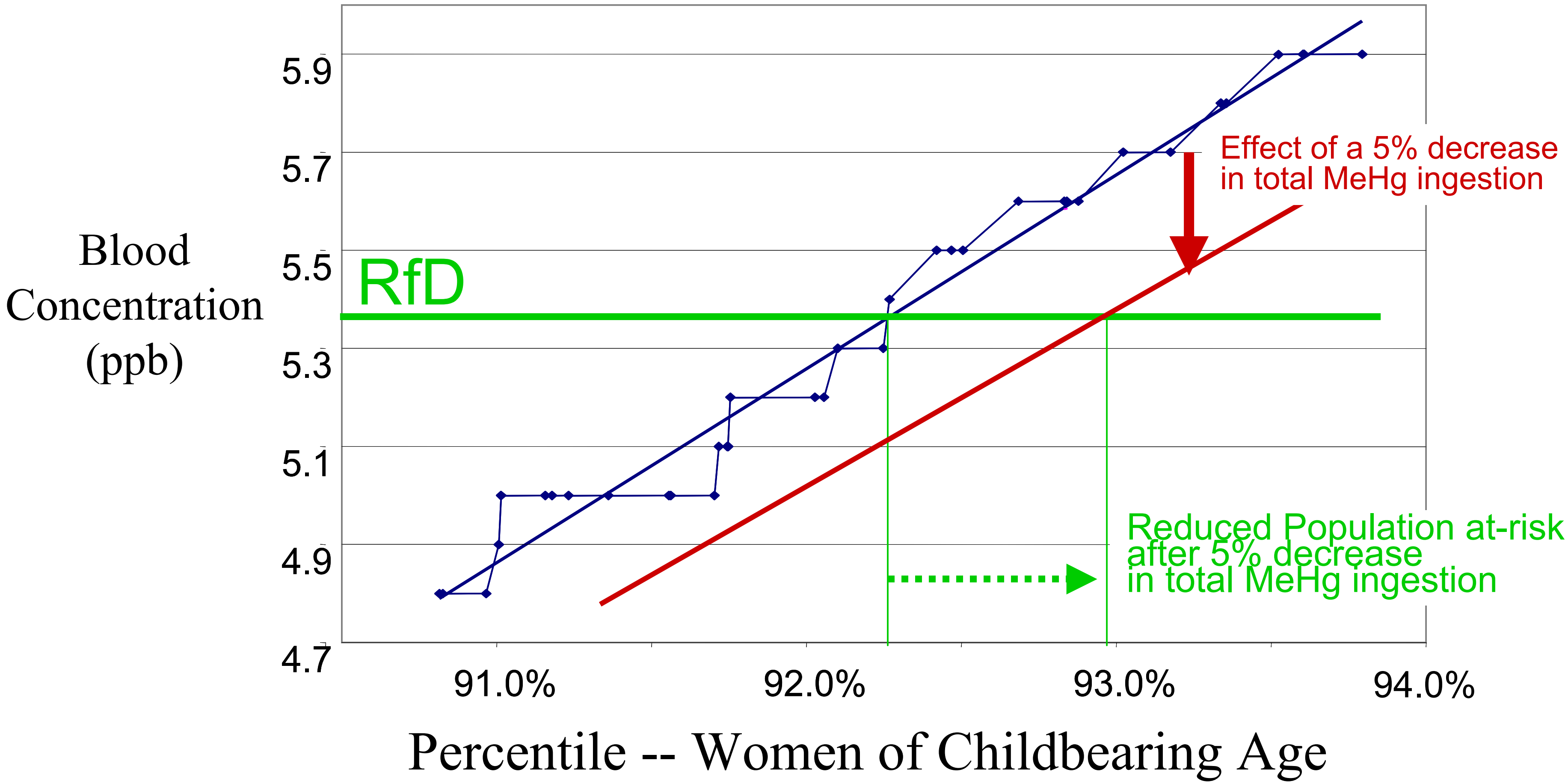
NHANES Data Used For Estimating Base Case MeHg Blood Levels

- Upper tail of cumulative distribution of blood MeHg levels for women of childbearing age estimated statistically.
- Entire distribution is shifted downwards by % change in relevant fish ingested.
- Population "at risk" are those with blood MeHg levels above the Reference Dose.
- Likelihood of being pregnant is assumed independent of position on the distribution.

Using the Estimated Population Distribution (Upper Tail) from NHANES



Illustrative Calculations: Hg Provisions of the Clear Skies Act of 2002

Evaluation of the Clear Skies Act (CSA)

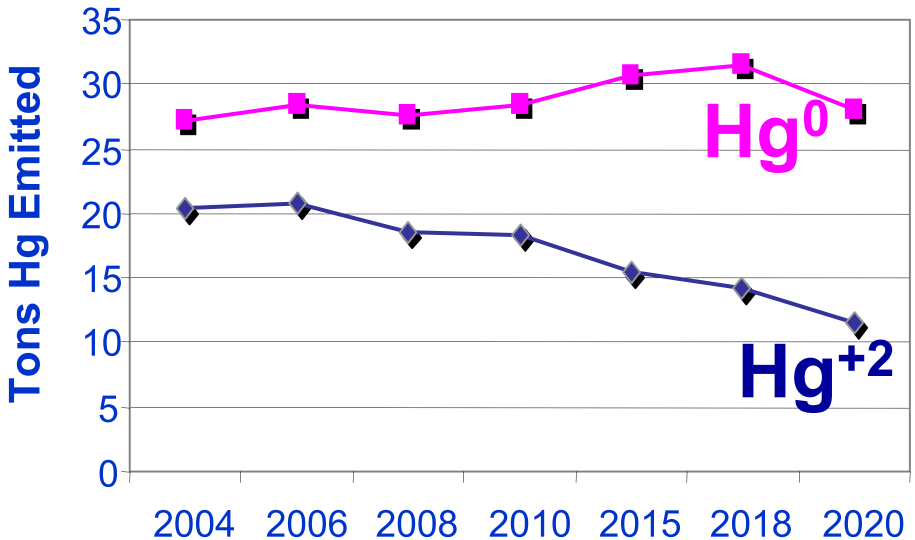
- **Base Case: CSA *without* its Hg controls**
  - **SO_2 cap of 4.5 million tons in 2010, 3 million tons in 2018**
  - **NO_x cap of 2.1 million tons in 2008, 1.7 million tons in 2018**
- **Scenario: CSA, *including* its Hg controls**
  - **Hg cap of 26 tons in 2010, 15 tons after 2018**
  - **Market based, cap-and-trade approach on national basis**
- **Still illustrative: estimates impacts on national average basis only.**

Speciated Emissions Trend

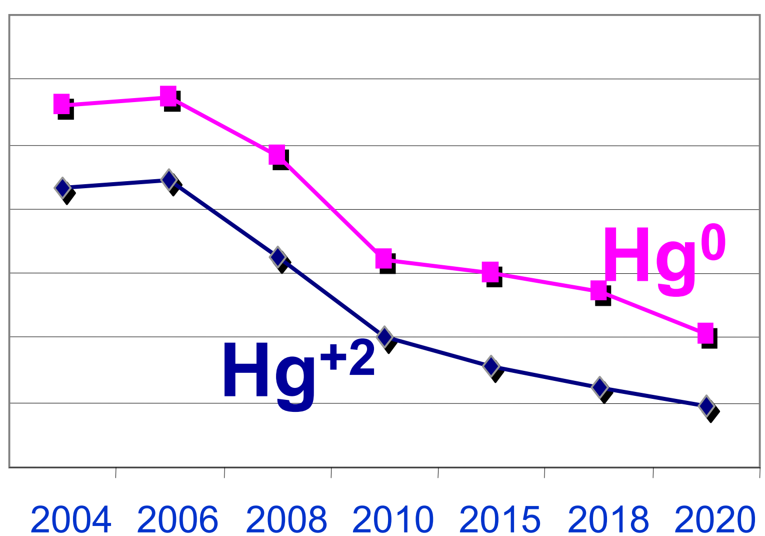
Preliminary & Illustrative

- Base Case trend reducing Hg^{+2} emissions.
- Addition of Hg caps to CSA has larger effect on Hg^{0}. Of a total Hg reduction relative to Base Case,
  - 6 tons of ionic Hg emission reductions.
  - 18 tons of elemental Hg emission reductions

Base Case (CSA w/o Hg caps)



CSA Scenario (w/ Hg caps)



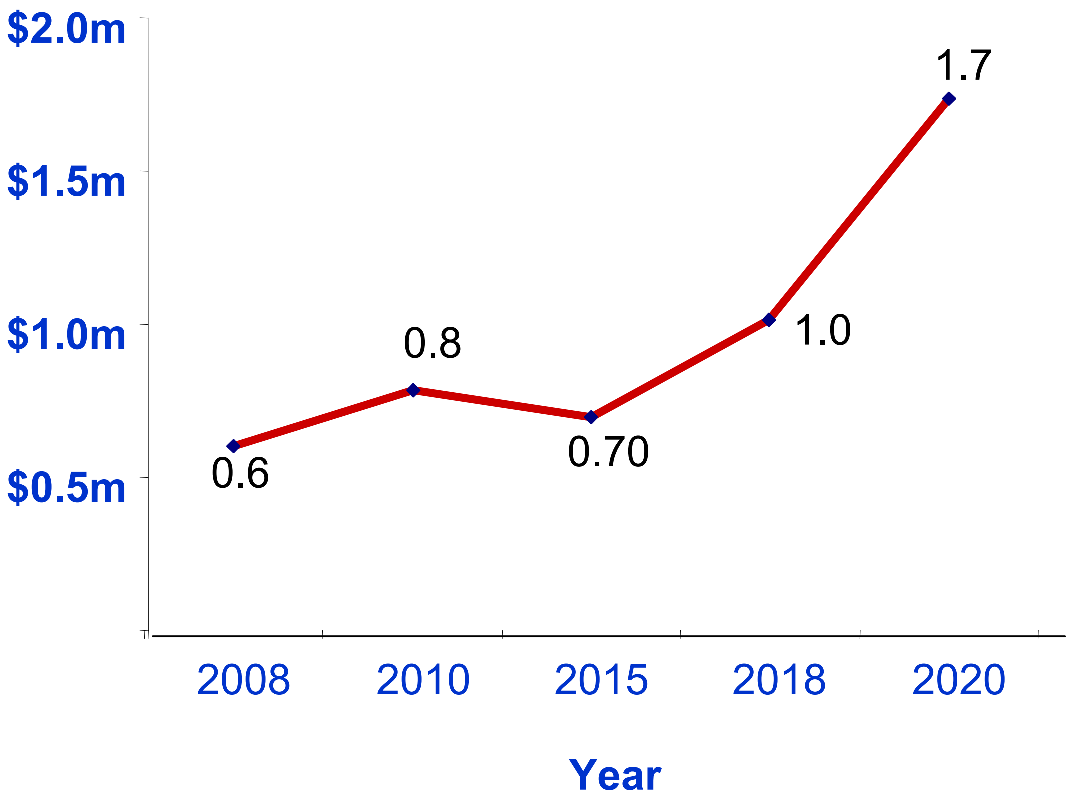
Hg Caps of CSA -- Cost-Effectiveness Summary

Preliminary & Illustrative

Year	Annual Costs ($m)	Deposition %Δ	% of Population > RfD	Inc. # Gestations < RfD
2008	$279	1.0%	-.010%	463
2010	$1,363	3.5%	-.034%	1,739
2015	$1,243	3.3%	-.036%	1,788
2018	$2,027	3.5%	-.034%	1,998
2020	$2,979	2.9%	-.029%	1,716

Cost Spent per Incremental Gestation < RfD

Preliminary & Illustrative



Next Steps

- Add regional detail.
- More types of scenarios (e.g., unit-specific vs. trading).
- Additional types of impacts?
- Incorporate new information as it becomes available.
- Add probabilistic simulation.
- Discuss significance of cost-effectiveness findings.
  - Are there more meaningful ways to assess cost-effectiveness?

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Philadelphia, Berkeley, Palo Alto, Salt Lake City, Austin, Houston
London, Brussels, Toronto, Mexico City, Wellington, Brisbane, Melbourne